academicJournals

Vol. 12(10), pp. 764-770, 9 March, 2017
DOI: 10.5897/AJAR2016.12075
Article Number: C0B1E4F63066
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

New type of trap for monitoring banana weevil population

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Received 13 December, 2016; Accepted 24 January, 2017

The objective of this study was to test the efficiency of a new model of trap by comparing it with the most recommended and used traps by producers to monitor *Cosmopolites sordidus* in areas of production of plantains. Three types of vegetable traps were tested: cheese, modified roof tile and a new trap called wedge. The experiment was carried out in five areas of production, measuring one hectare each, in which 20 traps of each type were distributed, totaling 300 traps. The traps were distributed fortnightly and the collections held weekly. The data of monthly averages of insects captured by trap were subjected to the F test for variance analysis in a randomized block design. The averages of the treatments were compared by the Tukey test at 5% probability. The average of *C. sordidus* adults caught in the wedge trap was superior to other traps tested, indicating greater attractiveness to insects. In this way, the use of this trap for monitoring banana weevil in plantations of plantains in the southern region of Bahia is recommended.

Key words: *Musa* spp., plantain, *Cosmopolites sordidus*, pest management.

INTRODUCTION

The plantains constitute one of the main starchy foods in developing countries. Brazil has no representation in the exportation of plantains, however all their production is destined to the domestic market. The production is estimated to be about 620 thousand tons, generating direct and indirect jobs, mainly for its majority family labor (Borges et al., 2015).

North and Northeast regions are the largest producers and consumers. Bahia State has the largest production areas, with emphasis on the lowlands of Bahia as the main production region. The planted area of this region is approximately 16.5 thousand hectares and its production is 285 thousand tons (Borges et al., 2015).

The plantains are highly susceptible to banana weevil,

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Figure 1. Types of attractive traps used for the capture of *Cosmopolites sordidus*: cheese (A), modified roof tile (B), and wedge (C) traps.

Cosmopolites sordidus (Germar), which is considered as the most economically important pest for *Musa* spp., due to its wide distribution and damage (Gold et al., 2001; Ostmark, 1974). The adult insect has nocturnal habits, sheltering during the day between the leaf sheaths of the plants, remains of the culture and rhizomes of plants harvested, which makes its observation by farmers difficult (Gold et al., 2001; Vinatier and Vinatier, 2013).

Recent studies demonstrated the relation between *C. sordidus* and phytopathogens of banana plant as the causal agents of the *Fusarium* wilt Race 4 (Meldrum et al., 2013) and bacterial wilt (Were et al., 2015). Therefore, this fact reinforces the need of banana weevil control, which might reduce disease spread. Some alternative methods have been evaluated for minimizing the economic damage posed by *C. sordidus* (Aby et al., 2015; Gold et al., 2001; Masanza et al., 2005; Reddy et al., 2008; Tinzaara et al., 2007; Uzakah et al., 2015).

It is essential to understand the population dynamic of banana weevil to establish the measures of control of that pest. The monitoring is carried out by using vegetal traps made of pieces of pseudostem or rhizome (Cordeiro and Fancelli, 2008; Price, 1995), whose compounds attract the adults of banana weevil (Budenberg et al., 1993; Ndiege et al., 1996; Tinzaara et al., 2007). The most used are those of type roof tile and cheese (Mesquita et al., 2014).

These traps can be used as a method of control, however, the efficiency of capture of adults of *C. sordidus* is very low and the results are only achieved at long-term (Gold et al., 2001; Mesquita et al., 2014). Thus, researches have been conducted to determine sample models of the insect (Maldonado et al., 2016) as well as to increase the efficiency of capture of adults by evaluating different types of vegetal traps incorporated or not to the biological control (Aby et al., 2015; Navas Rivera, 2011).

The objective of this study was to test the efficiency of a new model of vegetal trap as compared to the most recommended and used traps in the monitoring of *C. sordidus* by producers in areas of production of plantains.

MATERIALS AND METHODS

The experiment was conducted in areas that produce plantain cv. Terra, located in the city of Tancredo Neves, Bahia, located at 13°23'793' S, 039°19'945' W at 122 m above sea level, from December 2014 to February 2015.

Three types of traps were used: cheese trap; modified roof tile (sandwich) trap, and the new model, called wedge trap, all made from pseudostem of harvested plants. The cheese trap was made by cutting the pseudostem, approximately 30 cm from the ground level, and making a new cut (partial) at the half of that height (Figure 1). The modified roof tile trap was obtained from the half of a piece of pseudostem of approximately 60 cm length, cut in two parts in the longitudinal direction. In this way, the pieces of pseudostem were overlaid and placed near the plant. To make the wedge trap, initially, the pseudostem was leveled at 50 cm height. Then, two cuts were made in the pseudostem approximately 15 cm above the ground in the V-shape horizontal, in which the superior part formed an angle of 45° in relation to the cut surface below, parallel to the ground level (Navas Rivera, 2011).

The experimental design was in randomized blocks in a 3 x 3 factorial scheme (three types of traps and three months of evaluation), with 5 replicates. Twenty traps of each type were distributed in each block, fortnightly, totaling 100 traps randomly distributed in 5.0 hectares of the production areas. The collections of the insects were conducted weekly, at 7 and 14 days after the distribution of the traps, when new traps were made, adopting the same procedure for the counts and collections of insects. For the evaluation of efficiency, a weekly accounting of the number of insects per trap was carried out. The adults captured were later destroyed in order to evaluate the potential use of traps as a strategy of pest control.

The data of monthly averages of insects captured per trap were subjected to F test of variance analysis. The averages of treatments were compared with the Tukey test at 5% probability. Statistical analyses were performed using the statistical software Sisvar (Ferreira, 2014).

Meteorological variables (rainfall, air temperature, global

Table 1. Meteorological variables collected for each period of evaluation during the months of December 2014 to February 2015.

Period of evaluation	Relative humidity (%)	Air mean temperature (°C)	Air maximum temperature (°C)	Air minimum temperature (°C)	Global radiation (MJ m^{-2} day^{-1})	Rainfall (mm)
1	84.4	23.7	24.3	23.1	19.7	48.0
2	85.0	24.3	24.8	23.9	18.5	139.8
3	86.0	24.5	24.9	24.0	16.9	119.2
4	84.2	24.3	25.0	23.8	23.3	32.2
5	81.5	24.4	25.0	23.8	25.2	10.2
6	83.8	24.1	24.7	23.5	22.3	27.4
7	80.2	24.3	25.0	23.8	25.0	5.0
8	81.2	24.9	25.5	24.3	24.3	17.6
9	79.4	24.9	25.5	24.2	25.4	1.3
10	79.7	25.5	26.2	25.0	22.8	0.1
11	81.7	24.9	25.6	24.3	22.6	5.6
12	87.8	24.0	24.5	23.5	13.8	15.8

Table 2. Summary of variance analysis for the average number of captured *Cosmopolites sordidus*.

Sources of variation	DF	Mean square
Area	4	470.06^{ns}
Month	2	295.70^{ns}
Trap	2	1,167.91**
Month x trap	4	288,74^{ns}
Experimental error	32	180,07
CV (%)		8.14
Average		165.76

**Significant by F test at 1% probability; ^{ns}, not-significant by F test at 5% probability.

Table 3. Total number of adults of *Cosmopolites sordidus* collected per type of trap and per month.

Type of traps	Area (ha)	Number of traps	Total number of trapped insects*			
			December	January	February	Total
Wedge	5	100	1132 (2.83)	860 (2.15)	1019 (2.55)	3011 (2.51)
Roof tile	5	100	656 (1.64)	731 (1.83)	847 (2.12)	2234 (1.86)
Cheese	5	100	842 (2.11)	786 (1.97)	586 (1.47)	2214 (1.85)

*Average number of trapped adults of *C. sordidus*/trap in brackets.

radiation and air relative humidity) were monitored daily (Table 1) and correlated with population density of the insects considering the twelve periods of assessments.

RESULTS AND DISCUSSION

There was no significant difference in the number of adults of *C. sordidus* considering the interaction between the month of evaluation and the type of trap (Table 2). However, a significant effect from the type of trap was noticed. The wedge trap type attracted more insects (3011) than those of modified roof tile (2234) and cheese trap (2214), contributing about 40% of the total of insects captured (Table 3). The average number of insects captured in the wedge trap (201) was statistically higher than the values recorded for modified roof tile (149) and cheese traps (148) (Figure 2A). In this way, the wedge trap was more efficient than the others. The number of captures recorded for the trap of modified roof tile was

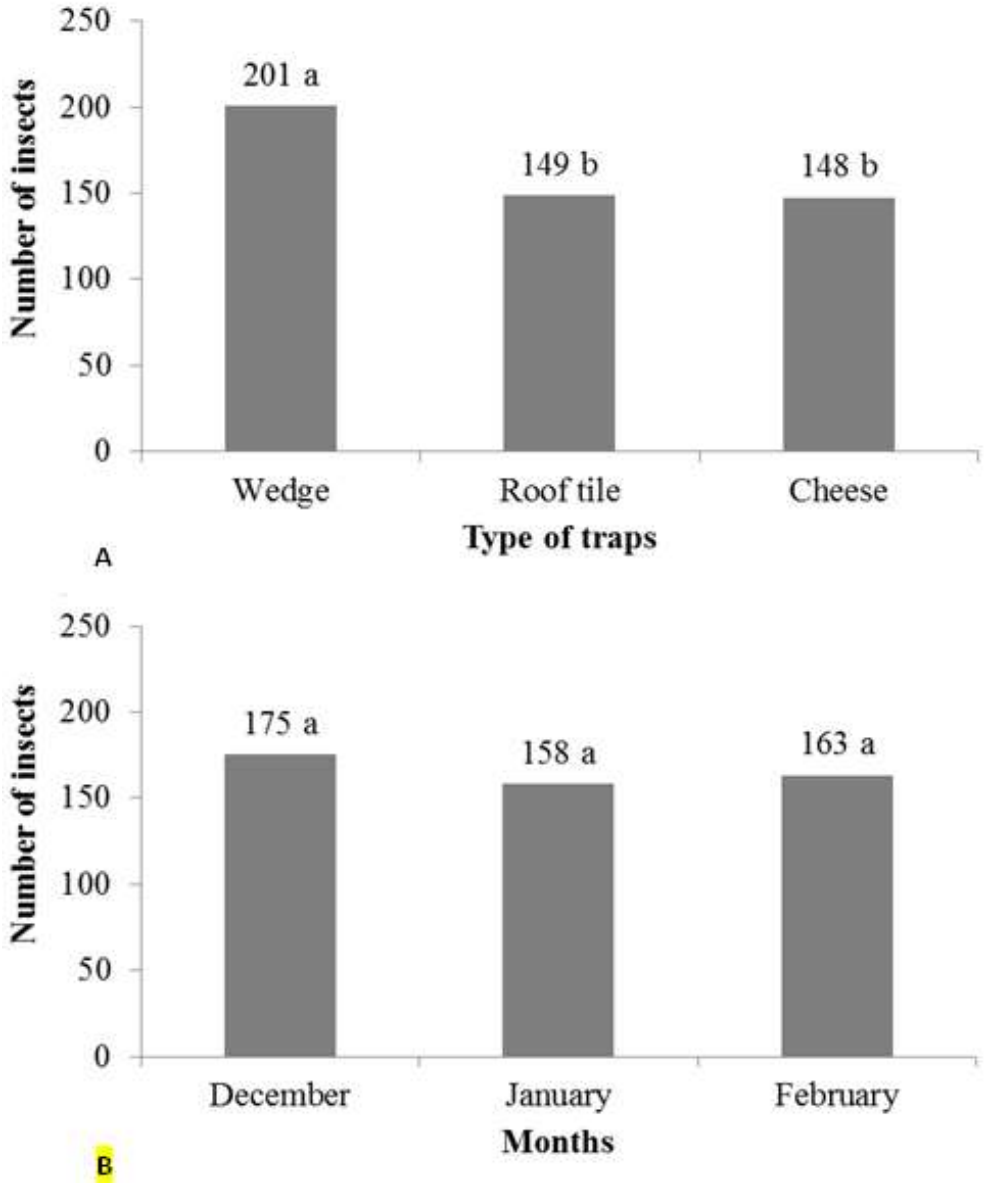

Figure 2. Average number of adults of *Cosmopolites sordidus* captured due to the type of traps (A) and the months of collection (B) (averages followed by the same letters do not statistically differ from each other by Tukey test at 5% significance level).

similar to the cheese trap, denoting its superiority as compared to the typical roof tile standard (Cordeiro and Fancelli, 2008; Gold et al., 2001).

There was no significant influence of the month on the number of adults of *C. sordidus* captured (Table 2). The values recorded for the months of December, January and February were 175, 158 and 163, respectively (Figure 2B). There was no significant correlation between the number of adults captured in the traps with rainfall, which contradicts the data obtained by Duyck et al. (2012) and Price (1995) (Table 4), but partially corroborates the results of Reddy et al. (2008) for nine of the ten locations evaluated in studies proving the efficiency of traps containing aggregation pheromone.

There was a significant and negative correlation among the values for adults captured in the wedge trap and temperature (minimum, mean and maximum) (Table 4). However, there was a negative and significant correlation between global radiation and capture in the wedge trap. Therefore, the reduction in *C. sordidus* trapping may be more related to exposure to radiation than to temperature itself. The same was observed for cheese traps, although there was no significant correlation between trapping and temperature.

Table 4. Spearman correlation between the climatic variables and the number of insects captured in each type of trap.

Variables	Type of traps		
	Wedge	Cheese	Roof tile
Air minimum temperature (°C)	-0.64*	-0.31^{ns}	-0.25^{ns}
Air mean temperature (°C)	-0.72**	-0.40^{ns}	0.20^{ns}
Air maximum temperature (°C)	-0.75**	-0.43^{ns}	0.18^{ns}
Rainfall (mm)	0.39^{ns}	0.32^{ns}	-0.02^{ns}
Global radiation (MJ m^{-2} day^{-1})	-0.71**	-0.78**	0.11 ^{ns}
Relative humidity (%)	0.83**	0.76**	-0.16^{ns}

*Significant at 5% probability; **significant at 1% probability; ^{ns}not significant at 5% probability.

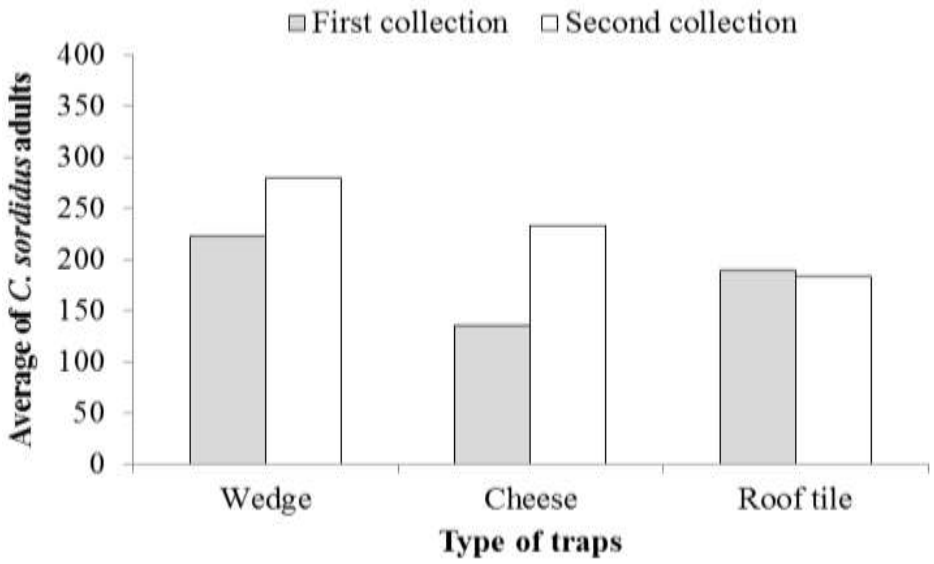

Figure 3. Average of adults of *Cosmopolites sordidus* on each collection per type of traps.

A significant and positive correlation was observed between the number of insects captured for wedge and cheese traps and the average relative humidity (Table 4). In this case, the highest relative humidity caused a greater capture of insects as a result of the best condition of the trap, because the adults are highly hygroscopic, corroborating the results of Gold et al. (2001) and Ostmark (1974).

Analyzing the average of adults monthly captured, it was observed that the values are closer to the inferior threshold for the insect control level, which varies from 2 to 5 insects per trap (Cordeiro and Fancelli, 2008) (Table 3). In addition, it was noticed that the traps of cheese and modified roof tile underestimated the number of adults captured. Considering that the action threshold is based on the average of adults trapped, this underestimation may lead to a delay in the implementation of control measures. Consequently, it might contribute to increase larval damage, in view of the great susceptibility of plantains to the pest (Fancelli et al., 2013; Gold et al., 2001).

The highest attractiveness of traps wedge can be attributed, in part, to its durability in relation to others, since the highest number of capture of adults was recorded on the second week of collection (Figure 3). Thus, to monitor this pest, a biweekly distribution of wedge traps, with two weekly assessments of the number of adults is recommended. As the efficiency of wedge traps was higher than the other trap types, manual collecting of insects using this kind of trap may constitute a good option for pest control, if properly evaluated. This can be especially useful in systems of organic production, where chemical control is not allowed. However, the results are only achieved at long-term (Gold et al., 2001; Mesquita et al., 2014). On the other hand, predators (Abera-Kalibata et al., 2007; Koppenhofer et al., 1994

and Ostmark, 1974) can contribute to improve biological control of *C. sordidus*. In addition to monitoring the insect through traps, it is recommended to assess the infestation either through direct evaluation in the rhizome (Borges et al., 2015; Carval et al., 2016; Cordeiro and Fancelli, 2008) or through non-invasive methods in development, such as the use of bio-acoustic sensors (Vinatier and Vinatier, 2013). However, in systems of conventional production, due to limitation of labor for this activity, the concomitant use of biological or chemical insecticides or synthetic pheromones is recommended (Cordeiro and Fancelli, 2008; Fancelli et al., 2013; Gold et al., 2001; Mesquita et al., 2014; Navas Rivera, 2011).

Particularly, for plantains, where the appearing of the rhizome is common, the low cut made to obtain the wedge and cheese traps could be a positive factor in the capture of a greater number of insects by exposure of rhizome and release of compounds responsible for their attractiveness (Budenberg et al., 1993; Ndiege et al., 1996; Tinzaara et al., 2007). However, this fact only occurred for the wedge trap, possibly due to the connection between rhizome and pseudostem provided by the partial cutting of the rhizome, contributing to a greater release of compounds in this type of trap and its appropriate humidity content. On the other hand, the effect of pheromones of aggregation (Duyck et al., 2012; Tinzaara et al., 2007), sexual (Uzakah et al., 2015) and possible visual stimuli (Reddy and Raman, 2011) in the increase of the number of adults caught by the effect of the compounds of the host plant should not be discarded. Considering this fact, in case of no adoption of the chemical or biological control of the insects, it is necessary to destroy the traps after the last evaluation, since adults can lay eggs on the traps tissues, increasing its population instead of reducing it (Mesquita et al., 2014).

The ease and speed of the wedge trap manufacturing as another positive point in its use should be noted. Thus, the producer may take advantage of the time of harvest to make the wedge trap.

In conclusion, the attractiveness of the wedge trap for adults of *C. sordidus* was superior to the traps of modified roof tile and cheese, respectively. Consequently, the use of wedge trap could be recommended for monitoring the banana weevil in plantation of plantains in the Southern region of lowlands of Bahia. Furthermore, the modified roof tile trap can be used preferably for the typical roof tile in crops not yet harvested.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors appreciate Foundation of Support for Research of the State of Bahia (FAPESB) for the scholarship, producers of the city Presidente Tancredo Neves for the opportunity to conduct the experiment in their production area and José Carlos Neri dos Santos, Raimundo Santana and José Magalhães Neves for all support during the work.

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